Handheld Computers as Tools in Freshman Courses

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Abstract

The latest advance in miniaturizing personal computers is the handheld "pocket PC." Since Fall semester, 2001, the College of Science and Engineering at the University of Minnesota Duluth (UMD) has required incoming freshmen majoring in Engineering and Computer Science to purchase and use these devices in entry-level courses. This year-long experiment will determine whether or not handheld computers should be required of all majors in the College, and, if successful, will establish a new avenue of instruction for students in science and engineering programs at UMD.

In this experimental program, incoming students are required to buy the iPAQ handheld personal computer, manufactured by Compaq. The iPAQs are equipped with wireless communication capability to connect with wireless hubs distributed across campus, giving students access to the Internet and to email services through the handheld devices. The iPAQs are very capable devices, with 32 Megabytes of memory and a 6 x 8 cm touch-sensitive color graphics screen on which users can enter information using a stylus either through soft buttons, menus, or handwriting recognition. The computer operating system is a variant of the Microsoft Windows platform.

The iPAQ computers are being used in freshman courses in Engineering and Computer Science this year. Course instructors have developed various approaches to incorporating the devices into their curricula. Since the pocket PC is a computing platform that is new to academia, many different applications are being tested. The iPAQs can give students access to web pages on the Internet, and some instructors are using that capability in their courses. The iPAQs also can store libraries of information locally, giving students access to component data sheets, chemical properties, or other data deemed useful by the instructor of a particular course. Some instructors have developed custom software that runs directly on the iPAQ computers without requiring interaction through the wireless connection to the Internet.

This paper will report on the experiment at UMD requiring freshman students in Engineering and Computer Science to use the Compaq iPAQ pocket PCs this year, and will detail some applications that have been used in introductory courses.

Introduction

The College of Science and Engineering at the University of Minnesota Duluth is currently testing the feasibility of using the latest personal computer technology, handheld "pocket PCs," in its undergraduate curriculum. This academic year, 2001-2002, freshman students in the Engineering programs and in Computer Science are being required to purchase Compaq's pocket PC, the "iPAQ," for use in entry-level courses in those departments. This paper reports interim results of using the iPAQs in those introductory Engineering and Computer Science courses during Fall semester, 2001.

As with any new technology, time has been needed to find constructive ways to apply these iPAQs in the curriculum, and that effort is continuing. Faculty in the affected departments were provided with their own iPAQs from the College during the summer, 2001, to encourage them to gain experience with the devices and to prepare applications for use in their freshman classes. Different faculty members have found different ways to apply the iPAQs in their classes, with varying degrees of success. Certainly, there is still much to learn and many avenues to explore in making effective use of this new technology.

The Compaq iPAQs have many features that can be useful both during and outside of class activities. Functionally, they are very capable, with 32 megabytes of memory, I/O via a 6 x 8 cm touch-sensitive color graphics screen, an infrared link allowing transfer of files from one iPAQ to another, audio recording and playback, and a wireless network connection via a plug-in card that gives access through campus wireless hubs to the Internet and electronic mail capabilities. Certainly these devices offer a wealth of features that make a variety of educational uses feasible.

During the Fall semester, 2001, applications used on the iPAQs fell into three basic categories. The first application category used the wireless networking capability of the iPAQs to access resources on the Internet. The second application category used the iPAQs simply as storage devices to provide easy access to reference material useful in classwork. The third application category used software written by course instructors or their assistants that ran directly on the iPAQs without requiring access to remote resources. Each of those application categories is discussed separately below.

Wireless Access to the Internet

Probably the most glamorous application of the iPAQs, or pocket PCs in general, is their ability to access global resources through wireless connection to the Internet. The Internet provides paths to almost any information imaginable, and includes facilities that allow interaction with virtually any other computer user in the world via electronic mail. The possibilities seem almost limitless, and this feature of pocket PCs is perhaps the most

widely cited capability heard from advertisers, company executives, and academic administrators.

However, with current technology, these capabilities are available only when the user is within range (a few hundred feet) of a wireless hub with connections to the Internet. True, eventually through satellite communication or through some cell-phone-like network, this limitation may disappear. As is, though, interaction through electronic mail or through the Internet in general has a range limited by the range of the wireless hubs that give access to the global network.

Even when access problems are resolved, however, pocket PCs have serious limitations when it comes to interacting with resources meant for more typical computer users, caused by the very limited I/O available. The iPAQ, and other pocket PCs, have a palm-sized graphic display. Viewing a typical Internet web page designed for a full sized display requires scrolling around on the small screen, and does not allow full display of the page's information in the way intended by the designer of the web page. True, web pages can be designed to display effectively on the iPAQ, and it is even possible to have the software that displays the web pages determine what type of display device is in use so that the page can be formatted appropriately, but the vast majority of typical information pages available do not produce usable displays on the iPAQ device. Input is also a problem. Pocket PCs receive textual input from the user either through a tiny "soft" keyboard on the display or through software handwriting recognition from the stylus, neither of which allows for the full speed entry of information to which a computer user is accustomed on a standard keyboard. Thus, both the display, or output of information, and the entry, or input of information using the iPAQ is very limited, and interaction with Internet resources meant to be used with standard computer hardware is very frustrating.

The plus side of this type of application, of course, is that access IS possible, and Internet resources ARE available, if you are within range of a wireless hub and if you can tolerate the limited I/O capabilities of the iPAQ device. In some applications, this capability is all that matters, and in those situations, the iPAQ is a handy tool for accessing global information.

Information Storage

With 32 megabytes of storage in the iPAQ, lots of information can be packed into the small, handheld device. Having this information readily available to students in class or in laboratories greatly eases their need to look up details that would otherwise require checking reference books or even traveling to the library. This capability was used in several classes during Fall, 2001, as an easy way to make the iPAQ devices useful to students in their coursework. Information as simple as tables of ASCII character codes or protocols for standard interfaces were valuable resources for students in Computer Science classes. Students in the introductory Electrical and Computer Engineering digital circuits classes benefited from having the connection pins of laboratory components identified via diagrams stored on the iPAQ. Students were provided with copies of the

chemical periodic table stored on the iPAQ for use in Chemistry classes. One can imagine a tremendous amount of information stored in the iPAQ devices at finer and finer levels of detail, for whatever particular situation is appropriate for a specific class.

The downside of this type of application is the need for somebody to enter the information in a usable style. Once the information is in electronic form in a format that can be displayed readily on the iPAQ, students can copy it easily from one iPAQ to another using the infrared link built into the iPAQs. However, the information must come from someplace. Sometimes, tables or similar information can be copied from Internet sources, and then just stored locally on the iPAQ devices. Often, though, the information must be generated by the course instructor to match the particular format suitable for the course application and for the iPAQ display. This is a time consuming process, but once done, it provides a valuable tool for use by students.

One can certainly argue that simply storing static information on the iPAQ is a waste of the technology. That is a valid argument, but as an initial way to make the iPAQs useful in classroom or laboratory settings, it is an easy start. Such static information can mature and evolve into adaptive tables or interactive graphs, etc., that can conform to the particular situation being addressed by the student user of the information. Such enhancements would require development time on the part of the course instructor or an assistant, but would take better advantage of the iPAQ computing capabilities.

Custom Software

Finally, the third category of applications used during Fall, 2001, in this experiment of embedding the iPAQ into freshman classes involved custom software written for specific applications in the courses. This application category required the most investment of time on the part of the course instructor, but offered the best payoff in enhancing educational goals of the courses involved. By generating custom software to run directly on the iPAQ, network connections were not required, and the troublesome limitations of the I/O offered by the iPAQ were addressed in the software to minimize drawbacks.

Since the iPAQ is, after all, a programmable computer, this application area is truly unbounded. The only limitation is the creativity and imagination of the course instructor, and the time that he or she is willing to invest in developing iPAQ software for his or her class. This can be a serious limitation, since not all faculty are capable or interested in writing custom application software. As the iPAQ and other pocket PCs mature and become more common, software packages written by others will become available to run directly on the iPAQs without the need for Internet or other resources.

The most visible effort in this category of applications was expended by Computer Science in developing custom software for its introductory programming courses. This software used the graphical display capability of the iPAQ to animate such things as various sorting or curve fitting algorithms, for example. Using simple input from the stylus, students could customize a problem by setting parameters, and then run the program to display the effects of their choice of parameters on the system performance.

In Electrical and Computer Engineering, faculty made use of existing software tools provided with the iPAQ, such as Excel, to produce custom packages for specific tasks in their classes. For example, one application allowed students to enter the truth table for a digital combinational function and then displayed the resulting algebraic expression for the function it represented. Another application worked in reverse, taking an algebraic expression for a function and displaying the Karnaugh map, essentially a re-formatted truth table, for that function. One can imagine all sorts of simulators in the Electrical Engineering discipline that could run on the iPAQ, from logic simulators to electrical circuit simulators. Such software requires significant development effort, however.

Student Reactions

Student reaction to the required use of iPAQ computers in freshman classes has been mostly positive. The Computer Science department has led the way in embedding the iPAQs into their introductory computer programming curriculum. Engineering applications have so far been less dramatic, but engineering students in general are inspired by the hardware itself and generally have entertained themselves to a great extent with the iPAQ devices.

The strongest negative feeling expressed by students was the feeling that they were not getting their money's worth. At the start of Fall, 2001, students were charged $800 for their iPAQ computers, a significant amount. Some students felt that for that amount of money, use of the iPAQs should form a larger part of the course content than it did during that semester. The only response to that valid claim is that experience with the iPAQ will lead to more and more applications for it, and as its capabilities are better understood, it will become a larger part of the curriculum.

An important aspect of introducing the iPAQ device to students is the level at which it is presented. Yes, the iPAQ is a full-fledged personal computer. But, it is a very low-end personal computer, with very limited I/O and limited capabilities. It is sometimes hard to sell a low-end anything to students, let alone a low-end computer, especially to students who often already own desktop systems that equal or surpass those used by faculty. Instead, the iPAQ could be portrayed as a state-of-the-art pocket calculator, that, in addition, can perform computer-like accesses to information and that can run software comparable to that on their desktops. Students always like state-of-the-art, top-of-the-line things. Portrayed that way, the iPAQ is an easier sell to students.

Summary

Overall, the experience in incorporating the iPAQ pocket PC into Engineering and Computer Science freshman classes has been a positive one, and it will continue into Spring semester, 2002, with likely expansion to the rest of the science departments in the College of Science and Engineering in the Fall semester, 2002. Incorporating the device into the curriculum of freshman classes has been a time-consuming processes, but a rewarding one that promises numerous potential benefits. The word that has been used

most often on campus regarding the iPAQ computers is "potential." These devices have great potential for enhancing education in science and engineering. That enhancement, however, does not come for free, and requires a considerable investment of time and preparation on the part of the faculty to truly embed these devices into the curriculum.

Assuming that this experiment with iPAQs in the freshmen classes is deemed a success, application of these devices in sophomore and later classes will follow, requiring proportionally more commitment from faculty to make the devices useful and to give students their money's worth. As technology progresses, however, education cannot stand still. We have moved beyond the slide rule. We are moving beyond the pocket calculator. Tomorrow's future lies in the mobile computing power offered by devices such as the iPAQ pocket PC.

References

1. Web page www.compaq.com/showroom/handhelds.html for information on the iPAQ.

Biography

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Christopher R. Carroll received a Bachelor of Engineering Science from Georgia Tech, and M.S. and Ph.D. degrees from Caltech. After teaching in Electrical Engineering at Duke University, he is now Associate Professor and Assistant Head of Electrical and Computer Engineering at the University of Minnesota Duluth. His interests include special-purpose digital systems, VLSI, and microprocessor applications.